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GB 2263582 A EP 0756298 A2 EP 0512718 A1
US 3898595 A

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(54) Abstract Title
**A laminated transformer and a method of its manufacture**

(57) A transformer and a method of its manufacture comprise: stacking insulating layers 1, 2, 4, 5, 6 in which first and second layers 4, 5 include at least one intermediate layer 6 comprising a closed loop of magnetic material 7. A plurality of conductive vias 8 - 11 are arranged in a plurality of sets, with each winding of the transformer relating to a respective pair of conductive via sets. One set of vias, of each pair of via sets, is located inside the loop of magnetic material 7 while the other set is outside the loop. Each pair of via sets are interconnected by the first and second layers 4, 5 such that they form a respective transformer winding. The insulating layers may be ceramic tape which are held together by sintering. The magnetic material loop 7 may be ferromagnetic material printed on or embedded in the layer 6. The interconnections on layers 4, 5 may be formed by printed conductors. Multiple transformers may be formed during manufacture which are later divided into separate transformers.

Fig 2

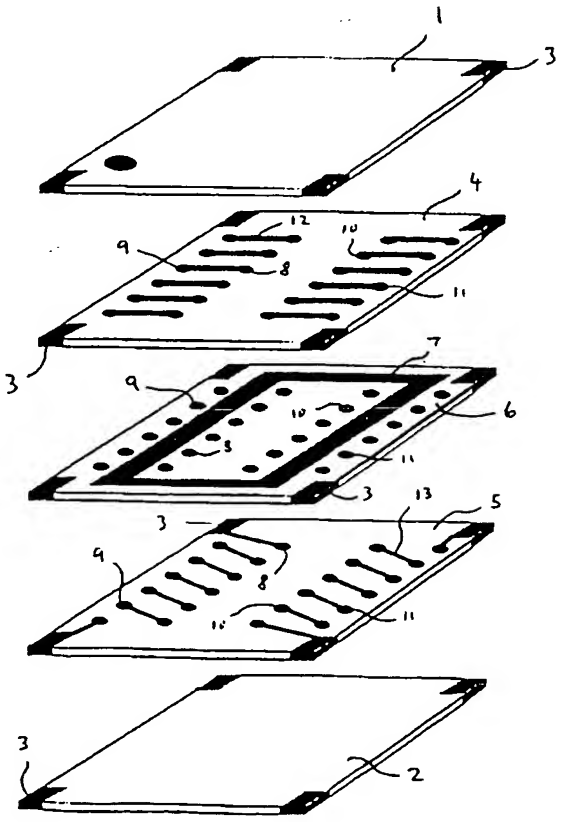


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Fig 1

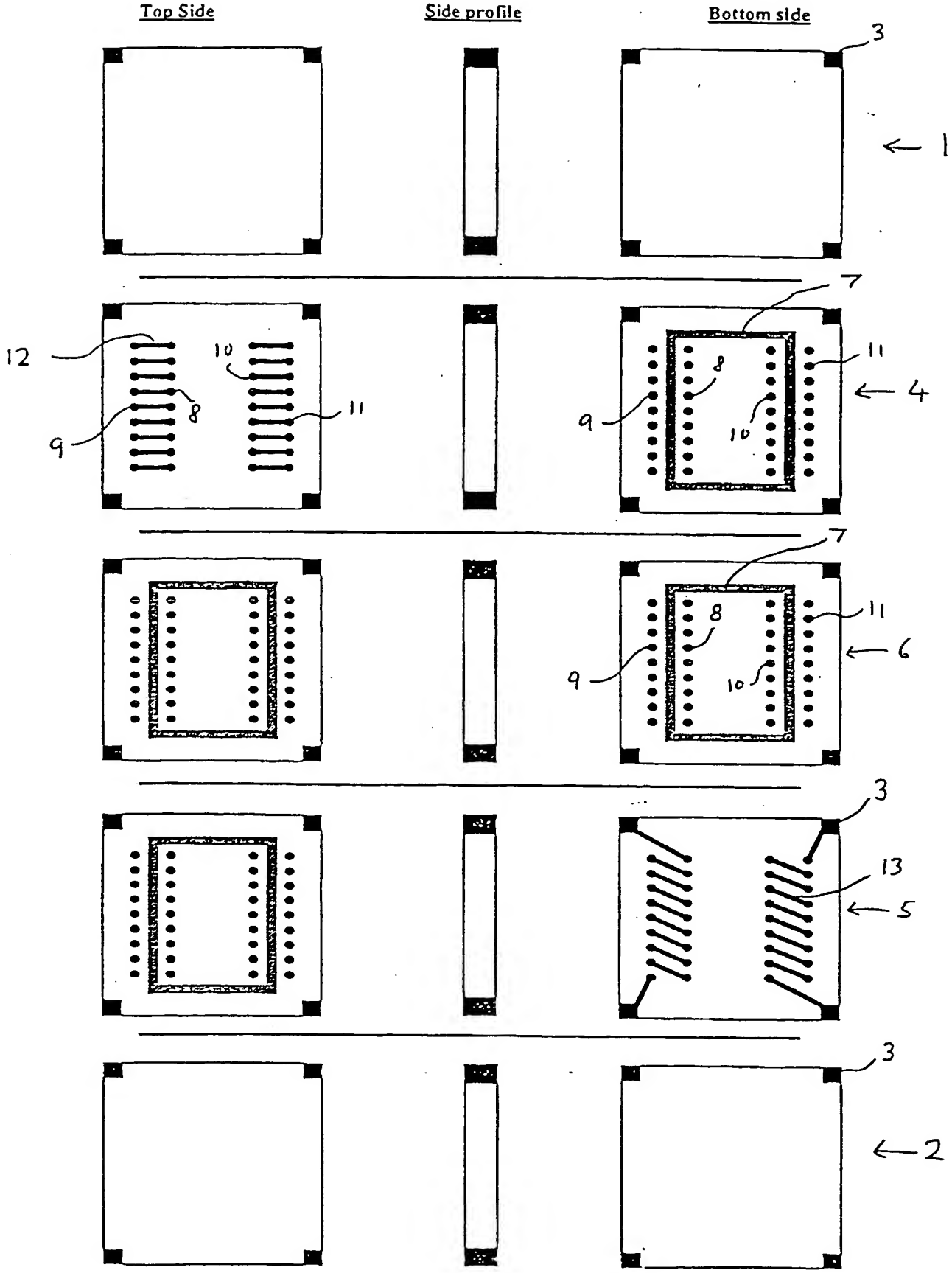


Fig 2

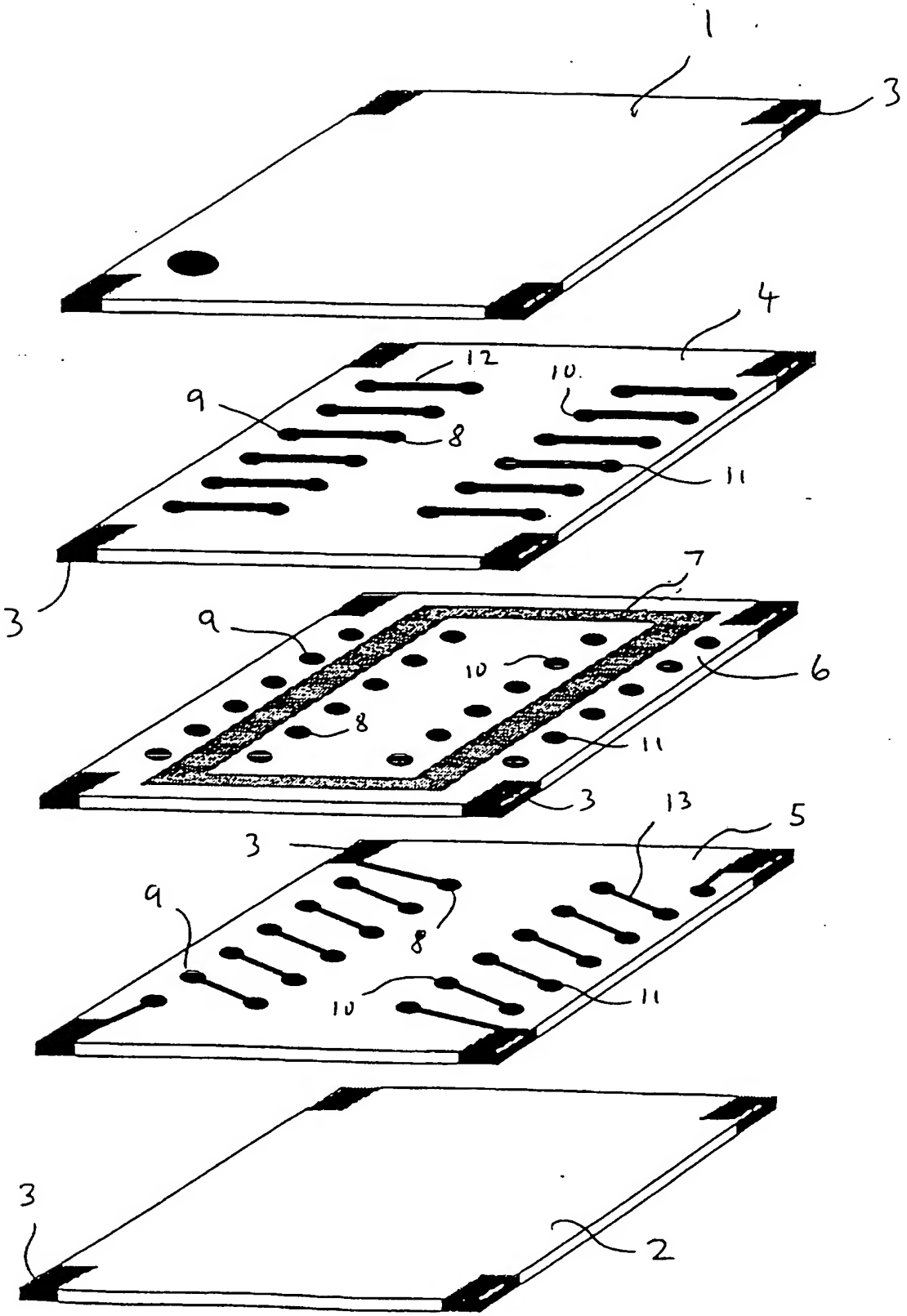
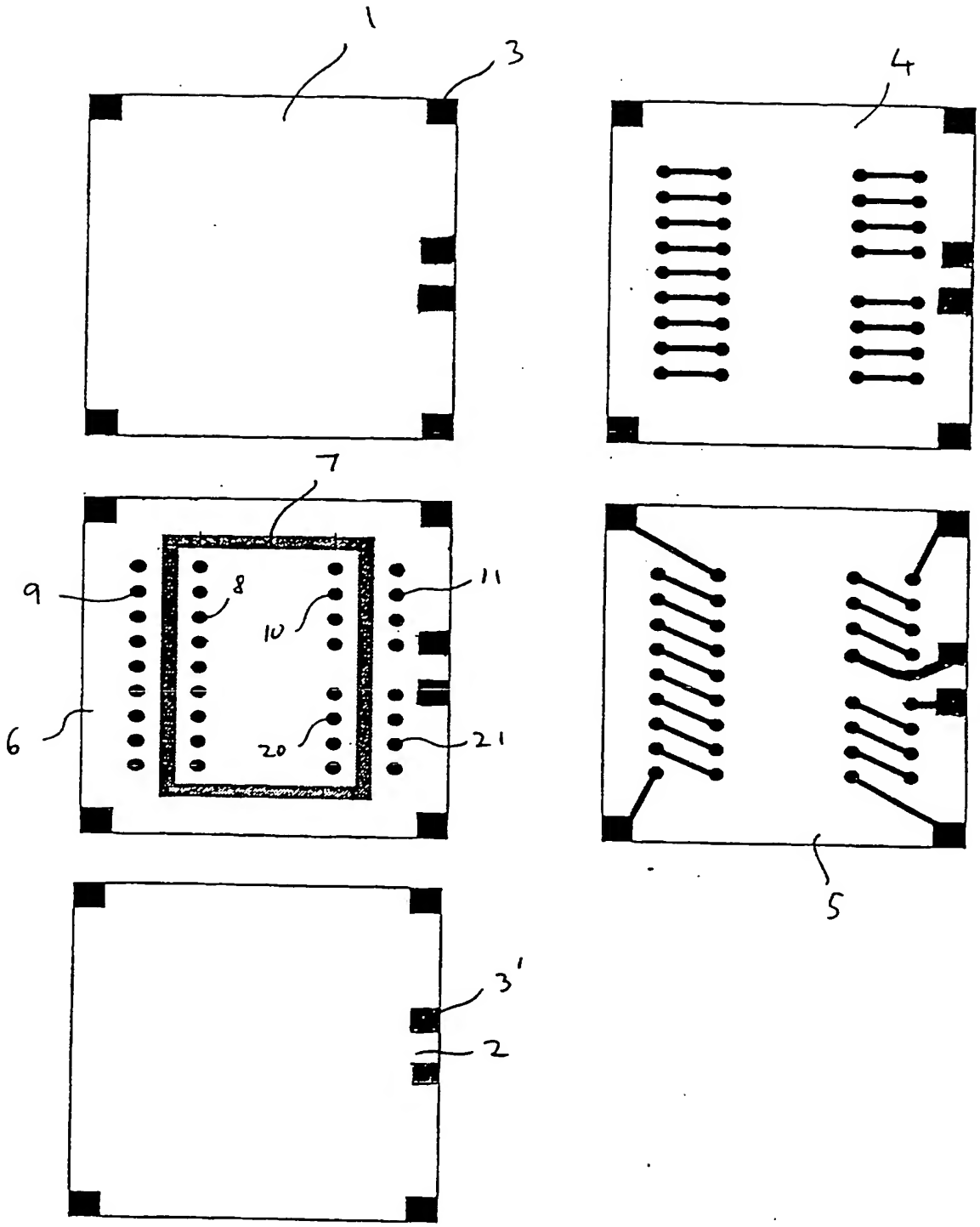


Fig 3



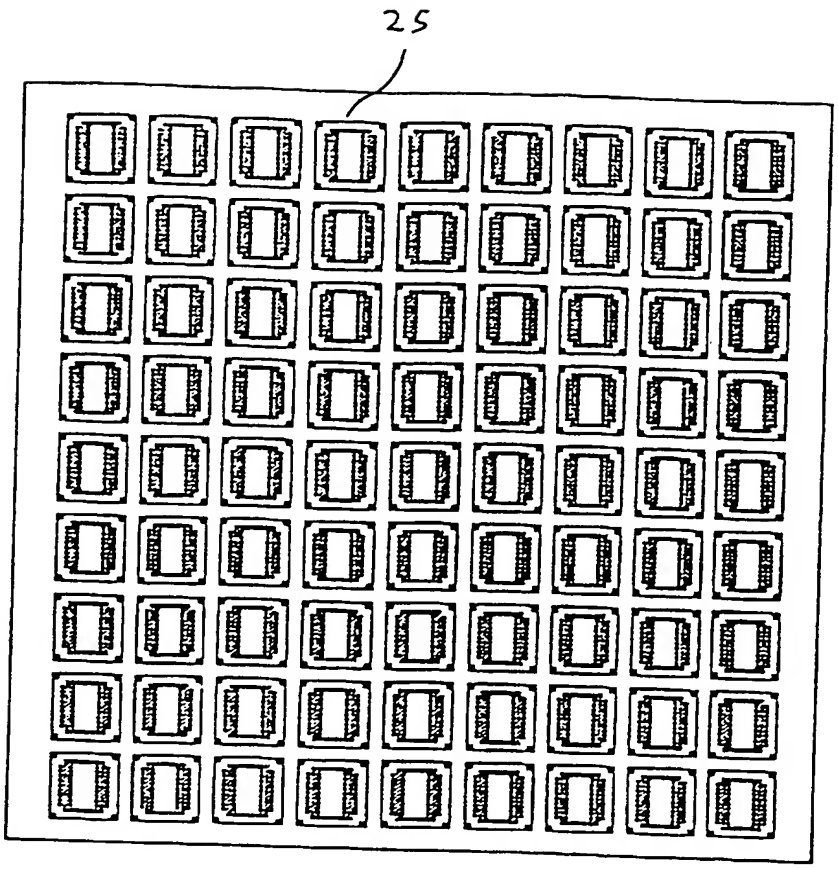



Fig 4

# Transformer and Method of Making a Transformer

The present invention relates to a transformer and to a method of making a transformer. One example of possible use of such a transformer is as an isolation barrier of a data access arrangement (DAA).

In a known type of DAA which provides, for example, an interface between a telephone line and equipment connected thereto, an opto-coupler is used for transferring information across an isolation barrier. Although such an arrangement provides isolation which is capable of withstanding relatively high voltage levels, it is necessary to provide additional circuitry which must be actively trimmed in order to ensure an accurate level of transfer ratio for digital and/or analogue signals.

According to a first aspect of the invention, there is provided a transformer as defined in the appended claim 1.

According to a second aspect of the invention, there is provided a method of making a transformer as defined in the appended claim 7.

Preferred embodiments of the invention are defined in the other appended claims.

It is thus possible to provide a transformer which is relatively easy and cheap to manufacture and which is capable of providing isolation between relatively large differences in voltage levels. An accurate level of transfer ratio can be provided without requiring active trimming or additional circuitry.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which;

Figure 1 illustrates the top side, side profile and bottom side of a plurality of layers forming a transformer constituting an embodiment of the invention;

Figure 2 is an exploded diagram illustrating how the layers shown in Figure 1 are stacked;

Figure 3 shows an alternative arrangement of layers for providing a transformer having three windings and constituting an embodiment of the invention; and

Figure 4 illustrates how a plurality of transformers may be made.

Like reference numerals refer to like parts throughout the drawings.

Figure 1 shows five layers of insulating material, such as ceramic tape, which are assembled together to form a transformer. The uppermost and lowermost layers 1 and 2 are substantially plain and provide electrical isolation for the other layers. These layers 1 and 2 merely have vias such as 3 at the corners thereof for providing connections to the ends of the transformer windings.

The transformer further comprises first and second layers 4 and 5 separated by one or more intermediate layers 6 (only one shown in the drawing). The intermediate layer 6 has embedded therein a rectangular closed loop 7 of a flux carrying medium. The loop 7 may be embedded in the layer 6 by any suitable technique. For example, the loop 7 can be formed by printing a suitable flux carrying medium on the layer 6. Suitable flux carrying media include, but are not limited to, ferrites and iron based materials. A plurality of vias are formed in the intermediate layer 6. The vias may be formed, for example, by punching or otherwise forming holes in the layer and filling these holes with an electrically conductive material, for example by plating. For the transformer shown in Figure 3 having two windings, the vias are arranged as two pairs of sets. One of these pairs comprises a first set of vias such as 8 disposed inside the loop 7 and a second set of vias such as 9 disposed outside the loop. Similarly, the other pair comprises a first set of vias such as 10 disposed inside the loop 7 and a second set of vias such as 11 disposed outside the loop 7.

The layer 4 likewise comprises a loop 7 of a flux carrying medium on its lower surface and an identical pattern of vias 8 to 11 to that on the intermediate layer 6. However, on its upper surface, the layer 4 comprises printed conductors such as 12 which connect together the sets of vias of each pair.

The upper surface of the layer 5 is identical to the lower surface of the layer 4 and each surface of the intermediate layer 6. However, the lower surface of the layer 5 comprises printed conductors such as 13 which also interconnect the first and second sets of vias of each pair. The lower surface of the layer 5 also provides end of winding connections to the vias 3 which permit external connection to the transformer.

The layers 1, 2, 4, 5 and 6 are assembled together to form a stack as illustrated in Figure 2. For the sake of illustration, the layer 5 is shown with the layout of its lower surface on its upper surface. The layers are held together under pressure and are then subjected to a high temperature firing process which causes sintering of the layers so as to fix the stack together. This provides a sealed component with the internal conductors being isolated from the environment. The vias 8 to 11 and the conductors 12 and 13 form two windings around respective limbs of the flux path 7 so as to provide an isolation transformer which is capable of providing isolation between circuit nodes at relatively large voltage differences. Connections to the ends of the windings are provided by the vias 3 and the transformer is suitable for surface mounting. It is also possible for the transformer to be formed integrally with associated circuitry, for instance by using a circuit board as one of the layers 1 or 2.

The transformer illustrated in Figures 1 and 2 provides two windings in the form of a primary winding and a secondary winding. However, any number of windings may be provided and Figure 3 illustrates an arrangement of layers for providing a transformer with three windings in the form, for example, of a primary winding and two secondary windings. In addition to the vias 3 at the corners of all of the layers, two additional vias such as 3' are provided for external connection.

Only one surface of each of the layers is shown in Figure 3. The intermediate layer 6 differs from that shown in Figure 1 in that an additional pair of sets of vias 20 and 21 is provided. The upper and lower surfaces of the layers 4 and 5, respectively, differ from those shown in Figure 1 in that the printed conductors are arranged to provide independent connections to the two windings on the right hand limb of the loop 7 replacing the single winding shown in Figure 1. In practice any number of windings may be provided within the physical limitations.

Figure 4 illustrates how a plurality of transformers may be made together so as to reduce the cost of manufacture. Each of the patterns of flux carrying medium and electrically conductive material for forming the individual transformer layers is formed as a respective region on a relatively large insulating layer such as a ceramic tape. Figure 4 shows an array of 9-by-9 regions such as 25 which will ultimately define an intermediate layer of the transformer. The appropriate patterns are repeated for each layer so that the individual regions are aligned when the layers are stacked.

As described hereinbefore, the layers are stacked and held together under pressure while being fired so that the layers are sintered together by a process known as low temperature co-fired ceramic (LTCC). The regions are then separated from each other by any suitable process so as to provide 81 individual transformers.

## CLAIMS

1. A transformer comprising a plurality of layers of insulating material forming a stack and a plurality of vias arranged as a plurality of pairs of sets, the layers comprising first and second layers and at least one intermediate layer disposed therebetween, the or each intermediate layer comprising a substantially closed loop of a flux carrying medium with a first set of each pair of sets of vias being disposed inside the loop and a second set of each pair of sets of vias being disposed outside the loop, the first and second sets of vias of each pair being connected together on each of the first and second layers so as to form a respective transformer winding.

2. A transformer as claimed in claim 1, in which each of the layers is made of a ceramic tape.

3. A transformer as claimed in claim 1 or 2, in which the or each loop of flux carrying medium is a printed loop of flux carrying medium.

4. A transformer as claimed in any one of the preceding claims, in which the first and second sets of vias are connected to each other on the first and second layers by printed conductors.

5. A transformer as claimed in any one of the preceding claims, in which the layers are held together by sintering.

6. A transformer as claimed in any one of the proceeding claims, in which the ferromagnetic material is embedded in the or each intermediate layer.

7. A method of making a transformer, comprising:
assembling a stack of layers of insulating material comprising first and second layers and at least one intermediate layer disposed therebetween, the or each intermediate layer comprising a plurality of regions, each of which comprises a substantially closed loop of a flux carrying medium and a plurality of pairs of sets of vias with a first set of each

pair being disposed inside the loop and a second set of each pair being disposed outside the loop, each of the first and second layers comprising a plurality of regions aligned with corresponding regions of the or each intermediate layer, the first and second sets of vias of each pair of each region being connected together on the aligned regions of the first and second layers so as to form a respective transformer winding; fixing the layers together in the stack; and dividing the stack so as to separate the regions in order to form a plurality of transformers.

8. A method as claimed in claim 7, in which the layers are fixed together by sintering.

9. A transformer substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

10. A method of making a transformer substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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**Application No:** GB 9906553.4 **Examiner:** J. A. Watt
**Claims searched:** 1 - 10 **Date of search:** 2 August 1999

# Patents Act 1977
# Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1T (T1C, T1F, T7A2B, T7C1B1)

Int Cl (Ed.6): H01F 17/00, 27/28, 27/30, 41/02, 41/04

Other:

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| Y | GB 2263582 A | (DALE ELECTRONIC) see figs.3 & 9 and page 10, lines 1 - 25 | 7 at least |
| X | EP 0756298 A2 | (AUTOSPLICE SYSTEMS) see figs.1 - 17 and col.1, line 41 to col.2, line 6 and col.5, lines 17 - 32. | 1 and 7 at least |
| X, Y | EP 0512718 A1 | (AT&T) see figs.14 - 20 and col.10, line 24 to col.11, line 11 | X: 1 at least<br>Y: 7 at lwast |
| X, Y | US 3898595 | (CUNNINGHAM) see fig.5 and col.5, line 64 to col.6, line 12 | X: 1 at least<br>Y: 7 at lwast |

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